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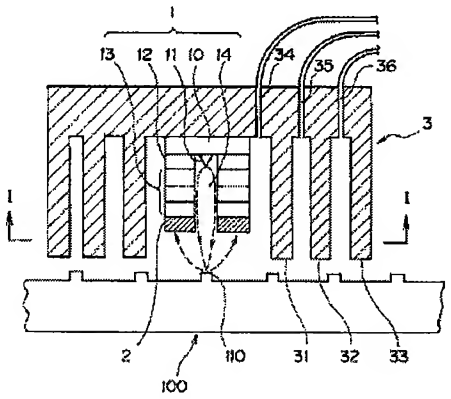
(54) [Title of the Invention] ELECTRON BEAM PROJECTION APPARATUS

(57) [Abstract]
[Object] An electron beam projecting device for irradiating an object with an electron beam and detecting the shape and other attributes of the object, wherein an object is to provide an electron beam projecting device in which the entire device can be made very small, the cost of the device can be increased, and the device can be applied to a variety of uses.
[Means of Achievement] A control electrode and cathode are each layered via respective insulating layers so as to enclose a cathode formed on a substrate to form a microscopic electron injection unit for irradiating an object with an electron beam; a detection unit for detecting secondary electrons from the object on which the electron beam is projected is formed on the anode; and a differential pumping unit is provided for producing a low vacuum condition in a space where the electron beam travels from the microscopic electron injection unit to the object, whereby the microscopic electron injection unit for emitting an electron beam can be miniaturized. The area where the electron beam is projected and detected can be kept in a low vacuum condition by using a simple differential pumping unit, whereby the secondary electrons amplified in the low vacuum area can be detected by the detection unit, and the detection accuracy can be improved.



[Claims]

Claim 1. An electron beam projection apparatus comprising:

microscopic electron injection means (1) in which a cathode for irradiating electrons is formed on a substrate, a control electrode is layered via an insulation layer in a manner enclosing the cathode, an anode is formed in layered fashion adjacent to the control electrode via an insulation layer in a manner enclosing the cathode, and an object is irradiated with an electron beam of electrons emitted from the cathode,

detecting means (2) formed on the anode of said microscopic electron injection means (1) via an insulating layer, for detecting secondary electrons emitted from the object irradiated with said electron beam; and

differential pumping means (3) for producing a low vacuum condition in the space where said electron beam travels from the microscopic electron injection means (1) to the object.

Claim 2. The electron projection apparatus according to claim 1, characterized in that said differential pumping means (3) comprises:

a plurality of ringed protrusions enclosing the microscopic electron injection means (1) on the same substrate as the substrate of said microscopic electron injection means (1); and

vents formed on a concave ditch part between said plurality of ringed protrusions

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention] The invention relates to an electron beam projection apparatus which detects the state of an object, such as shape, thereof by irradiating the object with an electron beam.

[0002]

[Prior Art] A scanning electron microscope (SEM) is known as one type of electron beam projection apparatus whose schematic structure is shown in Fig. 5. In an electron optical unit of the apparatus shown in the figure, fixed voltages are applied to the cathode [211], wehnelt [212] and anode [213] so that electrons are emitted from the cathode [211]. The electrons emitted from the cathode [211] are adjusted in the traveling axis thereof by alignment coils [220], converged by focusing lens [221] and irradiate a sample in fixed position via a stigma coil [222],

deflection coil [223] and objective lens [224]. Then the scanning electron microscope detects secondary electrons generated from the sample with the secondary electron detector [230]. The stigma coil [222] adjusts for astigmatism and the deflection coil [223] controls the direction of the electron beam. Also, the pumping system (not shown) connected to vents [250, 251] is provided in order to create a vacuum inside of the electron optical column.

[0003] In the scanning electron microscope, as described above, the internal air of electron optical column is evacuated via vents [250, 251], which produces a high vacuum condition therein. Under such high vacuum condition, the electrons emitted from cathode [211] are condensed and projected against the sample [100] as an electron beam. When the electron beam thus projected is incident upon the surface of the sample as primary electrons, secondary electrons are generated in response and are then detected by secondary electron detector [230]. From the secondary electrons thus obtained, the surface state of the sample is detected.

[0004]

[Problems to Be Solved by the Invention] Since the scanning electron microscope is constructed as described above, it requires a large-scaled electron optical system having various types of lenses and coils for the electron optical system. Further, a pumping system and a substantial electron optical column are also required in order to maintain a high vacuum condition inside the entire large-scaled electron optical system, so that the cost becomes very high and the whole system becomes very large in size and is complex. Consequently, the use of the apparatus has been limited to research and development due to their large size and high cost.

[0005] To solve the above-mentioned problems, it is an object of the present invention to provide an electron beam projection apparatus being totally miniaturized, lower-cost, and applicable for various uses.

[0006]

[Means Used to Solve the Above-Mentioned Problems] The electron beam projection apparatus of the present invention comprises microscopic electron injection means 1 in which a cathode for irradiating electrons is formed on a substrate, a control electrode is layered via an insulation layer in a manner enclosing the cathode, an anode is formed in layered fashion adjacent to the control electrode via an insulation layer in a manner enclosing the cathode, and an object is irradiated with an electron beam of electrons emitted from the cathode, detecting means

2 formed on the anode of said microscopic electron injection means 1 via an insulating layer, for detecting secondary electrons emitted from the object irradiated with said electron beam; and differential pumping means 3 for producing a low vacuum condition in the space where said electron beam travels from the microscopic electron injection means 1 to the object.

[0007]

[Operation of the Invention] In the present invention, a control electrode and cathode are each layered via respective insulating layers so as to enclose a cathode formed on a substrate to form a microscopic electron injection unit for irradiating an object with an electron beam; a detection unit for detecting secondary electrons from the object on which the electron beam is projected is formed on the anode; and a differential pumping unit is provided for producing a low vacuum condition in a space where the electron beam travels from the microscopic electron injection unit to the object, whereby the microscopic electron injection unit for emitting an electron beam can be miniaturized. The area where the electron beam is projected and detected can be kept in a low vacuum condition by using a simple differential pumping unit, whereby the secondary electrons amplified in the low vacuum area can be detected by the detection unit, and the detection accuracy can be improved.

[0008]

[Embodiments] a) First embodiment of the present invention

One embodiment of the present invention is described below by taking an example of an electron beam pickup for reproducing information from a recording disc with reference to Figs. 1 and 2.

[0009] Fig. 1 is a longitudinal sectional view of an electron beam projection apparatus, and Fig. 2 is a transverse sectional view corresponding to line I - I of Fig. 1. An electron beam projection apparatus includes a microscopic electron gun [1] fabricated by a manufacturing process technology used to produce semiconductor devices, that projects the electron beam onto a recording disc [100], and detectors [21 - 24] are arranged to enclose the injection muzzle [14] that injects the electron beam of this microscopic electron gun [1]. The four-divided detector part [2] detects the secondary electron beam emitted from the recording disc [100]. The electron beam projection apparatus further includes a differential pumping system [3] which produces a

low vacuum condition for the space where the electron beam from the microscopic electron gun [1] travels to the recording disc [100].

[0010] The microscopic electron gun [1] includes a cathode (or emitter) [11] which emits electrons and is formed in conical manner on a substrate [10], a gate (or Wehnelt cathode) [12] which is formed via insulating layer (not shown) as a lamination in a ringed manner enclosing the cathode [11], and an anode [13] which is formed via an insulation layer (not shown) as a lamination on the gate [12] in a ringed manner and operates as an electric lens system for converging the electron beam of electrons emitted from the cathode [11].

[0011] The four-divided detecting part [2] includes the four detectors [21 - 24], laminate-molded via an insulation layer (omitted in the figure) adjacent to the ringed anode [13] on the microscopic electron gun [1], and detects the secondary electrons emitted from the recording disc [100] irradiated with the electron beam. The differential pumping system [3] includes protruding ringed walls [31, 32, 33] formed as concentric circles enclosing the microscopic electron gun [1], and vents [34, 35, 36] formed in the concave ditch part of the base of ringed walls [31, 32, 33] and connected to the pumping apparatus which is not shown.

[0012] Next, the operation of the electron projecting apparatus will be described by taking the example of reading the information from the optional recording tracks [110] on the recording disc [100]. In the case of reading information from the recording track [110], the electron projecting apparatus serves as an information pickup (hereinafter referred to as "electron beam pickup") for the target recording track [110], positioned under the electron beam, of the plurality of recording tracks on the recording disc [100]. Above the recording rack [110], the air in a space between electron beam pickup and recording disc [100] is evacuated through vents [34, 35, 36] respectively in order to produce a low vacuum condition therein. Under the low vacuum condition, the electrons are emitted from the cathode [11] by the electric field generated from the proper voltage applied to the cathode [11], the gate [12], and the anode [13]. The emitted electrons are accelerated by the gate [12], and then condensed into an electron beam and focused on the recording track [110] by the three-stage laminated anode [13]. The spot diameter of this focused electron beam is limited to be not more than 10 nm.

[0013] When the focused electron beam is incident as primary electrons on the surface of the recording disc [100], the secondary electrons are emitted from the metal membrane of the surface of recording disc [100]. By applying the electric field from the recording disc [100]

toward the side of the detector part [2], the electrons emitted are drawn out by the electric field and accelerated. In such a case, if the gas pressure and distance from the recording disc [100] are properly selected in a low vacuum condition, the emitted electrons incident on the four divided detector part [2] can be amplified by the ionization of gas molecules. The adjustment of gas pressure is performed by the differential pumping system [3].

[0014] Other than secondary electrons, the primary electrons reflected by the surface of the recording disc [100] are also incident on the four-divided detector part [2]. However, it is possible to control the ratio of primary electrons and secondary electrons incident on the four-divided detector part [2] by controlling the electric field from the recording disc [100] toward the four-divided detector part [2], because when the electric field of the detector side is reduced, the secondary electrons incident upon the four-divided detector part [2] are correspondingly reduced. By this control, the information from the objective recording track [110] can be efficiently detected.

[0015] By calculating the different components of respective signals obtained from each of the four-divided detectors [21 - 24], edge information of the recording track [110] and tracking information on the recording track [110] are obtained. Further, RF signals of the recorded information are obtained by adding all of the detectable signals. In this way, the recording signal is reproduced from the recording disc [100] by properly controlling the gas pressure, the distance from the surface, and the electric field at the detector side, etc.

[0016] b) Second embodiment of the present invention

Although the above-described electron beam projecting apparatus has a single microscopic electron gun [1] and four-divided detectors in a single differential pumping system [3], it is possible to modify the composition to include a plurality of microscopic electron guns [1] and four-divided detector parts [2], respectively, in the differential pumping system [3], as shown in Fig. 3. In this case, it is possible to simultaneously examine (or reproduce) a plurality of positions on the surface of the objects with the four-divided detector parts [2] (particularly in the case of the reproduction of the recording disc, a plurality of recording tracks [110] can be efficiently read).

[0017] Moreover, as illustrated in Fig. 4 (A), the present invention can also be arranged to include a plurality of microscopic electron guns [1] and four-divided detector parts [2] provided to the differential pumping system [3] so as to be inclined with respect to the radial direction of

recording track [110]. By this inclined arrangement, the microscopic electron guns [1] and four-divided detector part [2] can be positioned to correspond to track pitches between mutual recording tracks [110] of the recording disc [100] recorded in high density.

[0018] Moreover, as illustrated in fig. 4 (B), a plurality of units can be aligned in the same direction as the radial direction of the recording track [110], and detection can be carried out with normally functioning detectors when one of the aligned detectors malfunctions. It is thereby possible to improve the yield of the manufacturing apparatus.

[0019] Furthermore, it is possible to arrange a plurality of microscopic electron guns [1] and four-divided detector part [2] furnished in the differential pumping system [3] to be aligned in a direction inclined with respect to the radial direction and further arranged as plural lines with fixed spaces therebetween in a direction perpendicular to the inclined direction, as shown in Fig. 4 (C).

[0020] In the above-described embodiments, the electron beam projecting apparatus serves as an electron beam pickup. However, it is also possible to compose the apparatus as a surface detection apparatus for detecting the surface state of the object. In such a case, it is possible to detect the reproduced signals with fine contrast corresponding to the uneven condition of the surface of the object by selecting gas pressure, distance from the surface, and electric field at detector side, etc., and controlling the detection ratio between primary electrons and secondary electrons.

[0021] In each of the previous embodiments, although the detecting part is composed of four-divided detectors, composition of other optionally-divided detectors can also be used. In each of the above-described embodiments, although the assembly of the differential pumping system and the microscopic electron gun are formed individual to each other, it is possible to form the differential pumping system by a manufacturing process technology for semiconductor devices on the same substrate where the microscopic electron gun is formed.

[0022]

[Effect of the Invention] As described above, an effect is obtained whereby a control electrode and cathode are each layered via respective insulating layers so as to enclose a cathode formed on a substrate to form a microscopic electron injection unit for irradiating an object with an electron beam; a detection unit for detecting secondary electrons from the object on which the

electron beam is projected is formed on the anode; and a differential pumping unit is provided for producing a low vacuum condition in a space where the electron beam travels from the microscopic electron injection unit to the object, whereby the microscopic electron injection unit for emitting an electron beam can be miniaturized. In addition, the area where the electron beam is projected and detected can be kept in a low vacuum condition by using a simple differential pumping unit, whereby the secondary electrons amplified in the low vacuum area can be detected by the detection unit, and the detection accuracy can be improved.

[Brief Description of the Drawings]

FIG. 1 is a longitudinal sectional view of an electron beam pickup according to an embodiment of the present invention.

FIG. 2 is a transverse sectional view of an electron beam pickup corresponding to line I - I of **FIG. 1**.

FIG 3 is a plan view of an electron beam pickup according to another embodiment of the present invention, and a cross-sectional view corresponding to line II - II of the plan view.

FIG. 4 is a plan view of respective pickups according to still another embodiment of the present invention.

FIG. 5 is a schematic illustration of an electron beam projection apparatus of prior art.

[Key]

1 ... microscopic electron gun

2 ... four-divided detecting part

3 ... differential pumping system

10 ... substrate

11 ... cathode

12 ... gate

13 ... anode

14 ... injection muzzle

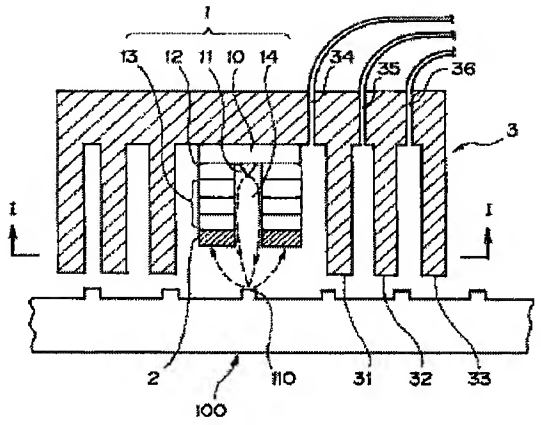
21, 22, 23, 24 ... detectors

34, 35, 36 ... vents

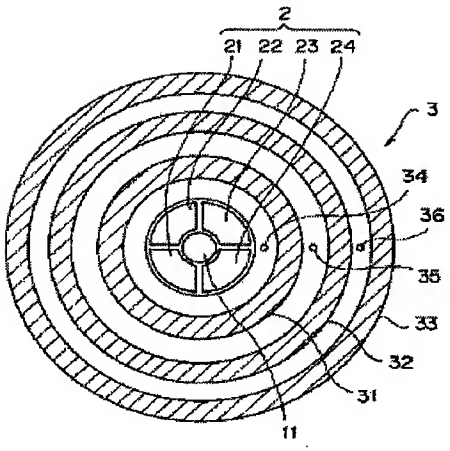
100 ... recording disc (object)

110 ... recording track

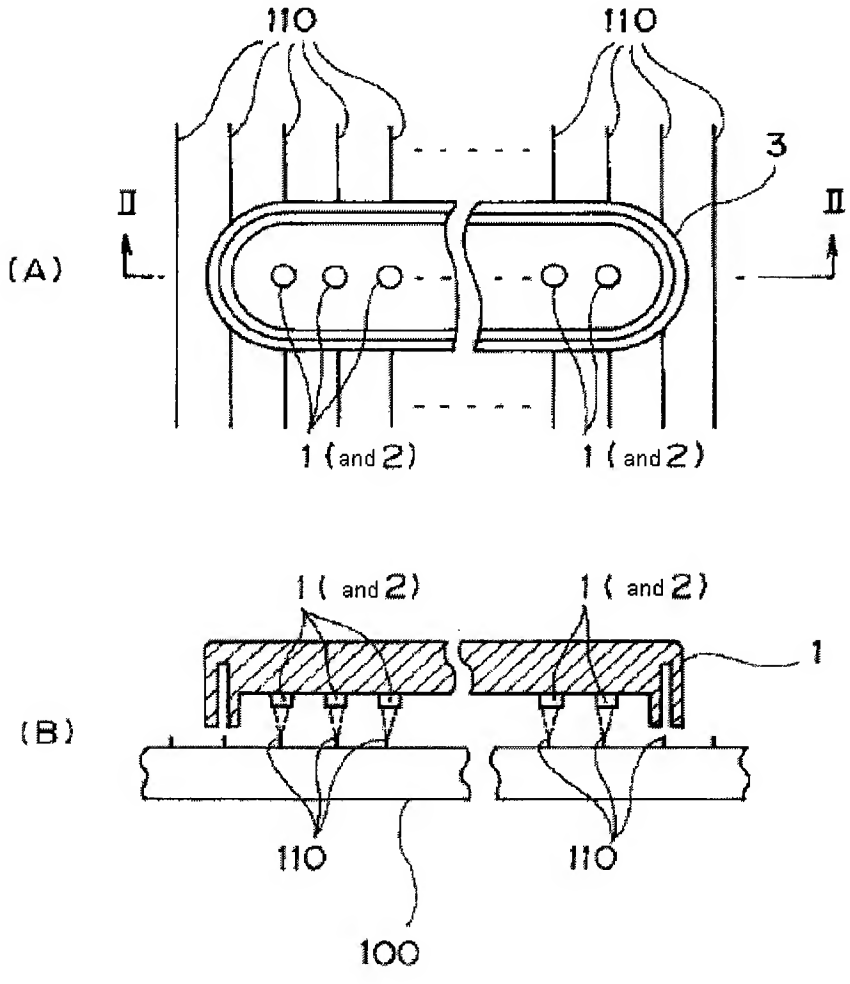
[Fig. 1]



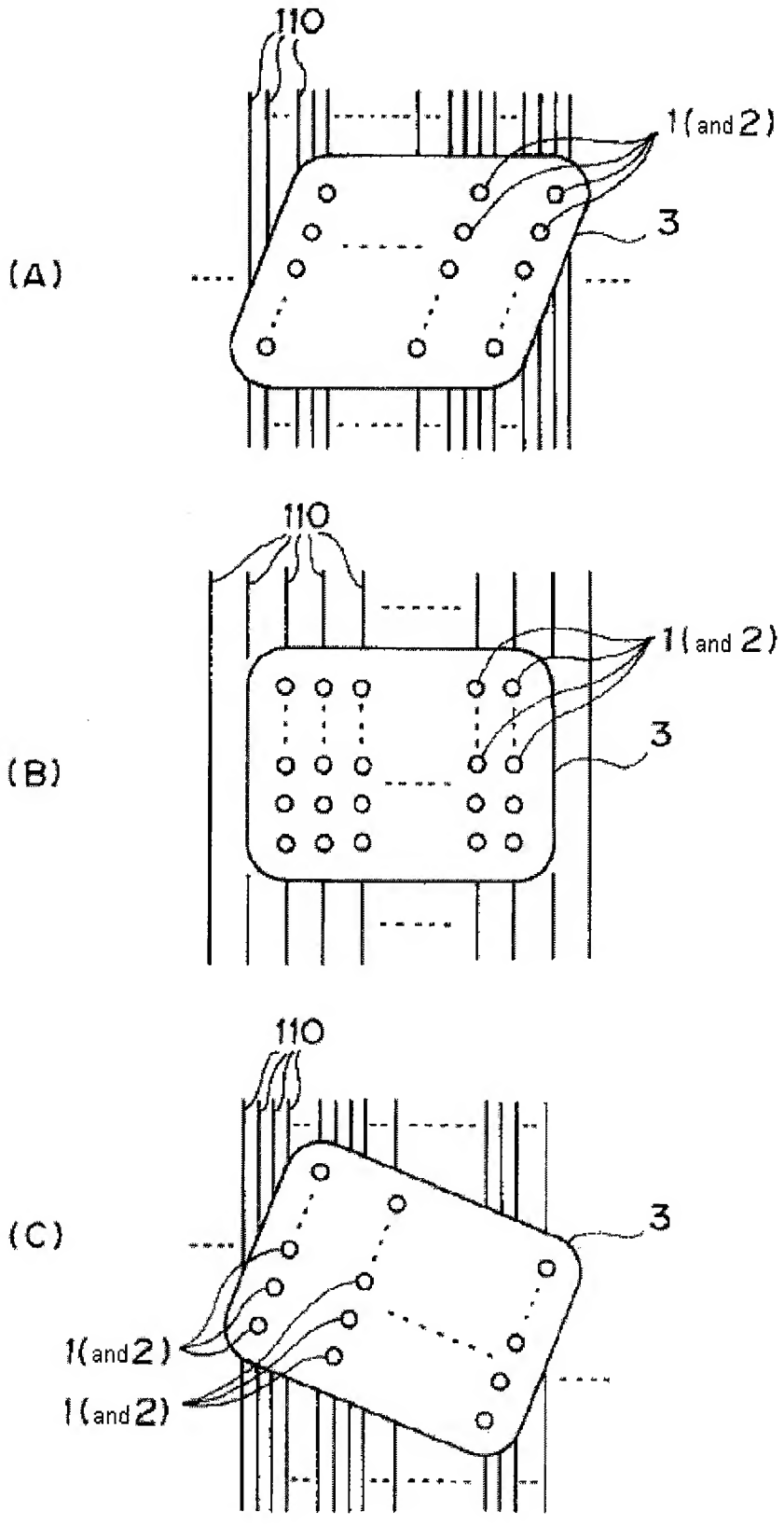
[Fig. 2]



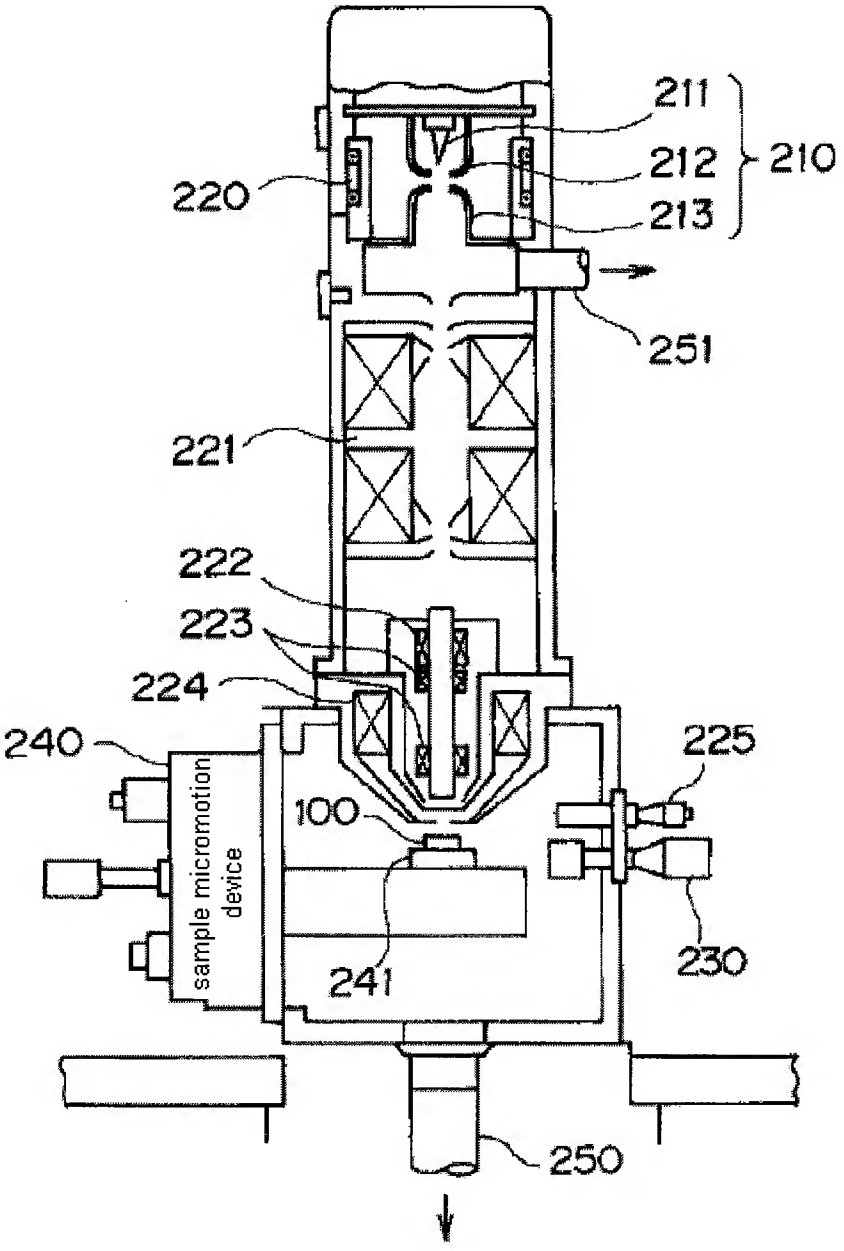
[Fig. 3]



[Fig. 4]



[Fig. 5]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